

Experiment on TiO_2/AC Photocatalysis Technique to Eliminate Toluene in Air Conditioning Systems

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Abstract : The aims of the paper is to enhance indoor air quality, improve occupant comfort, increase the effectiveness of those who are studying and researching new purifying techniques, and use a TiO_2/AC photocatalytic purifying web with an air conditioning system to control indoor environmental conditions.

The influences of the absorption characteristics of active carbon and TiO_2 photocatalytic oxidation on decomposing toluene are tested. The efficiencies of three kinds of purification webs to purify high concentration of toluene and low concentration of toluene are compared in static air. The factors of influencing the purification efficiency of the TiO_2/AC web are analyzed and tested.

Purification ability of TiO_2/AC web was found to be higher than single purification techniques in decomposing toluene, whether in high concentration or low concentration. The compound of TiO_2 photocatalyst and active carbon has the advantage of active carbon absorption and TiO_2 photocatalyst for decomposition. In addition, the resistance of TiO_2/AC photocatalysis web is minimal under different air speeds. The relation between purification efficiency and various influencing factors was analyzed in order to identify the best conditions for use of the TiO_2 photocatalytic web in air conditioning systems.

Keywords : Active carbon and nano-titanium dioxide photocatalysis; Toluene; Purifying Technique; Indoor air quality

1. INTRODUCTION

Progress of mankind culture is closely

correlative to new technique and new science knowledge. Removing the effect on human health of indoor contaminants and lifting IAQ, establishing well green indoor environment equally cannot parts from new technique and new science knowledge^[1]. As “SARS” emerging the notion of “indoor exterminated bacterium ”causes air-condition purification facility with higher technique to be created, which its nuclear notion is to decompose and

adsorb pernicious pathogenic bacteria and gas^[2].

Traditional air-condition is merely laid stress on regulating the indoor temperature and moisture, and no considering IAQ. Moreover in order to decrease the energy consumption, frequently adopting the littler the amount of fresh wind cause indoor contaminant concentration to increase. People who are revealed into the environment have easily the headache, vomiting, giddy mind and dim eyesight, transient losing anamnesis , nervous weary mind and mood is not steadied , and even cause nerve and respiratory system are subjected to be damage. According to the survey in DaLian, Wuhan, Xiamen, Anhui, Fujian, the carbon dioxide concentration obviously increase in the air-condition room and oxygen and the anion concentration obviously is lower than the ordinary room^[3]. Besides , a host of air-condition system in our country merely build up one step air filter, which merely be able to be validly filtrate the granule with more than $10\text{ }\mu\text{m}$, especially for the granule easily breathed , its effectiveness is lower.

At present, the techniques handling and

controlling tiny contaminants in air have been rapidly developed. In purification techniques such as active carbon adsorption method in early day and TiO_2 photocatalysis purification technique appeared in recent year have certain effect, and the techniques have already been applied to corresponding material and equipment. Through a large number of experiments, we discovered active carbon adsorption method and TiO_2 photocatalysis techniques have high purification efficiency in static environment. However, in dynamic system, such as in air conditioning system, as airflow velocity high and contaminants concentration low, their purification efficiency is very low. So solving the problems of air cleaning should start from the reality to research high-efficient purification techniques. According to the current situation of the air purification techniques and equipment applied and the character of contaminants in room with air conditioning system and development of purification techniques at present, the article proposes that new-type purification technique and hopes to promote the upgrading of the product about purification.

2. INTRODUCTION ON THE STRUCTURE AND STUFF OF ACTIVE CARBON AND NANO-TITANIUM DIOXIDE PHOTOCATALYSIS PURIFICATION WEB

What is called active carbon and nano-titanium dioxide photocatalysis technique is to utilize the method of compounding active carbon and nanometer photocatalyst to firstly form absorption layer on supporting body surface by gluing, which the goosy is gather ester emulsion acrylic acid and the active carbon is 6000 purpose high iodine value powder charcoal, shell charcoal, etc. and its thickness is about 1 cm, and then transform nanometer TiO_2 loading onto the active carbon powder particle as the most outer photocatalysis layer. The powder of TiO_2 (products is made by Company of P25DEGUSSA) are directly dispersed into water by the method of supersound dispersing to make the slurry that the firm quantity of reunion body is 0.05, and soak compounded carrier with

support body and active carbon for three times, then bake four hours under the condition of 160 and vacuum. Finally the shell structure that TiO_2 attached onto active charcoal surface is formed [4]~[5].

Experiment adopts windpipe type of active carbon and Nano-titanium Dioxide Photocatalysis purification web made in Japan, with ultraviolet lamp and air purification web by oneself.

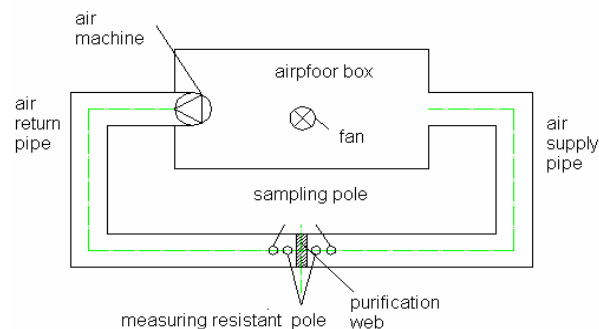


Fig.1 System Chart of the Experiment

Material on the supporting body of the web are adopted a kind of new-type corrugated cardboard to

glue each other, which two cardboard adjoin ripple of cardboard stagger certain angle to augment the area of contact between body and air and make air good fluidity among them at the same time. Solid base and powder material that form the web are analyzed by XRD and several characteristic peaks of XRD picture on the powder show that have sharp titanium TiO_2 , active carbon MPAC (capillary carbon) and ZMS-8 molecular. The little dense peaks have reflected that granule diameter of the material is between 10nm and 100nm.

In addition, in order to compare the capability of new purification technique make the test of capability about single purification technique, Nano-titanium dioxide photocatalysis purification and active carbon purification at the same time, which separately adopt windpipe-type TiO_2 photocatalysis purification web made in Japan and domestic windpipe-type active carbon purification web.

3. EXPERIMENT ON TEST OF

CAPABILITY OF ACTIVE CARBON AND NANO-TITANIUM DIOXIDE PHOTOCATALYSIS PURIFICATION WEB

3.1 Fitting of Experiment

Utilizing an airproof box simulates the air-conditioning room (parameter: the indoor temperature 20 and relative humidity 55%), which size of the box is $1.5\text{m} \times 1.5\text{m} \times 1.5\text{m}$ and made of wood and its thick is 5cm and using aluminum foil to airproof among boards. In addition, the air machine with frequency conversion supplies the driving force of air-blower and changes the wind quantity by changing the frequency of power supply. The purification web is joined by means of the flange between the windpipes.

3.2 Test Means

The test chooses to toluene as contaminant tested. The toluene detector is convenient to use and measure and the degree of its accurateness is very high. Toluene with specified concentration is injected into the box by sampling hole using the injector, and the steady flow electric fan is turned on to cause contaminant uniform to distribute in the box. After closing down the electric fan and the air machine, ultraviolet lamp is turned on to decompose contaminant. Every fixing time testing the change of toluene concentration through the sampling hole measures the capability of purification web. Every the time of sampling is 20s and accuracy of measurement is about 15%.

The airproof capability of the box need be tested. The method is to inject certain concentration toluene, then turn on the steady fan for an hour and measure the change of toluene concentration after toluene is even distribution in the box and continuously measure for 2 hours. Observing changes of concentration, we think the airproof capability of the box is very good and can take tests if the concentration is equal within the error^[6].

4. RESULTS AND ANALYSIS OF EXPERIMENT

4.1 Comparing the Capability of Three Kinds of Purification Web

Some researchers have studied the capability

of active carbon and TiO_2 photocatalysis purifying organic and inorganic contaminants, and discovered the effect of active carbon purifying inorganic contaminants such as carbon dioxide and ammonia is very bad and produced new contaminants in the course of TiO_2 photocatalysis purifying contaminants. Hence, making some experiments compare the capability of three kinds of purification web to purify toluene and ammonia.

Experiment adopts windpipe-type of active carbon and Nano-titanium Dioxide Photocatalysis purification web, active carbon purification web, Nano-titanium Dioxide Photocatalysis purification web to test the changes of concentration of toluene, which the time of testing is 14min and the result is following as Table.1^[7].

From the results we can see the purification effect of active carbon and Nano-titanium Dioxide Photocatalysis purification web is most prominent and its efficiency reaches 95.8%. The cause is that the active carbon can not only absorb contaminants in the web but also enrich the contaminants onto the surface of active carbon to supply the environment with higher contaminants concentration and accelerate the decomposition velocity of TiO_2 Photocatalysis oxygenation. Moreover during the purification there are not new contaminants to be produced, as active carbon can absorb immediately new contaminants and further to decompose for water and carbon dioxide.

4.2 Effect of Airflow Velocity on Active Carbon and Nano-titanium Dioxide Photocatalysis Purification Web Decomposing Toluene

The effect of active carbon and Nano-titanium Dioxide Photocatalysis purification web is following as Fig.2 separately under the condition of high toluene concentration, different air supply velocity for high and middle and low velocity. We can see the difference of effects between low and high air supply velocity is not obvious under the condition of high toluene concentration, which is less than 8%. It shows the technique can better overcome the disadvantages of other purification equipments, which purification efficiency is decreased when air flow velocity increase.

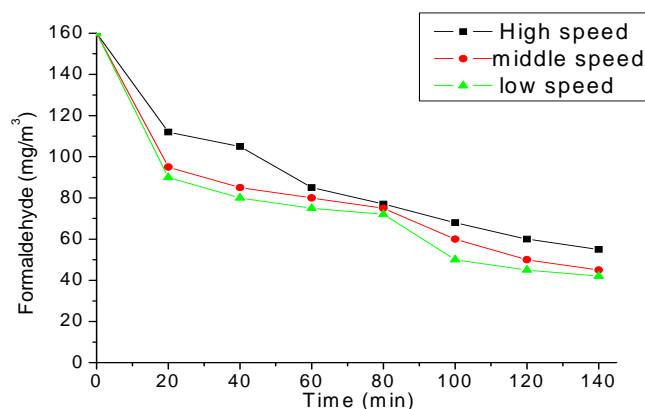
Tab. 1 Capability of three kinds of purification to toluene

Produced method	Concentration of toluene		P.E. (%)	By- product
	C_0	C_T		
AC/S	65	22.8	65	No
TiO ₂ /S	65	16.3	75	Yes
AC/TiO ₂ /S	65	0.80	95.8	No

S: support

 C_T : The final concentration of pollutants C_0 : The initial concentration of pollutants

P.E: Purification efficiency

**Fig.2 Concentration change of formaldehyde under different air**

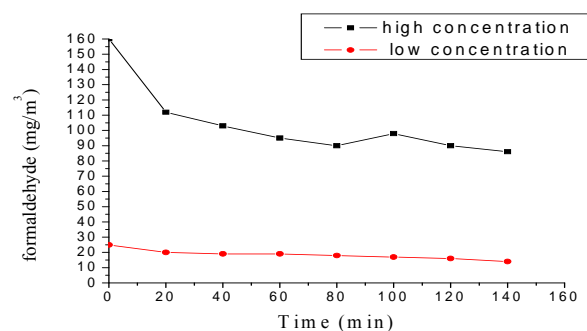
Nano-titanium Dioxide Photocatalysis Purification Web Decomposing Toluene

4.3 Effect of Original Concentration on Active Carbon and Nano-titanium Dioxide Photocatalysis Purification Web Decomposing Toluene

Under condition of stable temperature and humidity and airspeed of windward side, the relation between changes of toluene concentration and original concentration is following as Fig. 3, 4, 5.

The result can be seen that the effect of purification is more obvious to the higher original toluene concentration, and it can be explained by the law of quality action. However it can also be seen the difference of the effect of purification is not big under the different airspeed and same concentration and shows that active carbon and Nano-titanium Dioxide Photocatalysis technique can exert preferably the advantages of active carbon absorption and Nano-titanium Dioxide Photocatalysis oxygenation.

Through many experiments in the box, we can find that toluene concentration will be decreased and the efficiency of purification is enhanced with the temperature increased from the figure 7 and figure8. When the temperature reaches 25, the effect of TiO₂/AC purification web is optimal.

**Fig.3. High air speed**

4.4 Effect of Temperature on Active Carbon and

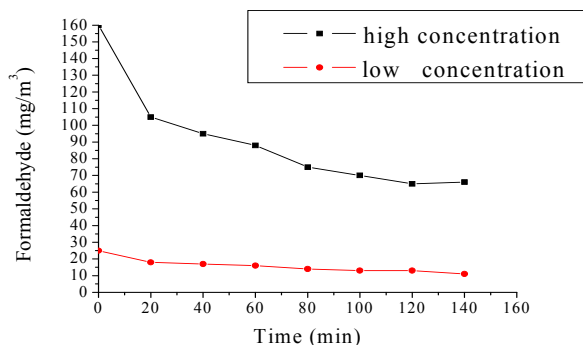


Fig. 4. Middle High air speed

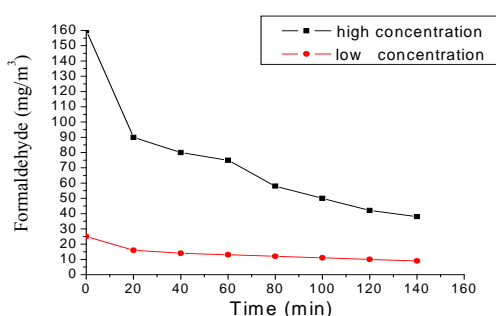


Fig. 5 Low air speed

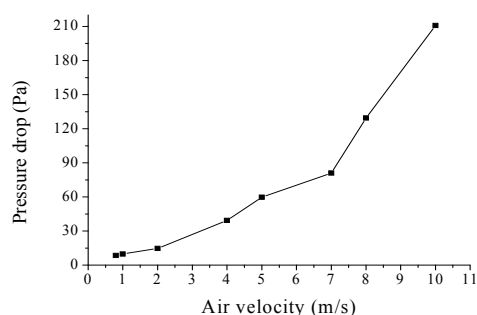


Fig. 6 The relation between velocity and pressure

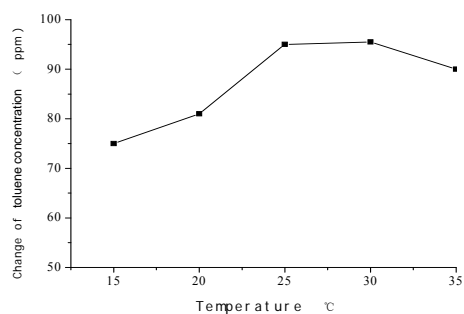


Fig. 7 Effect of Temperature on the Purification Web Decomposing Toluene

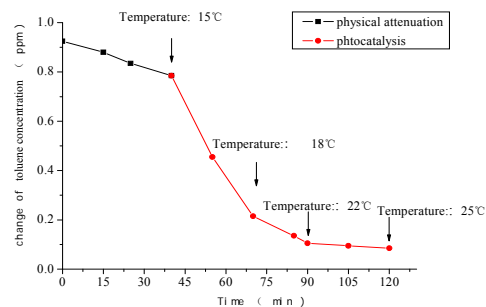


Fig. 8 Relation between changes of toluene concentration and temperature

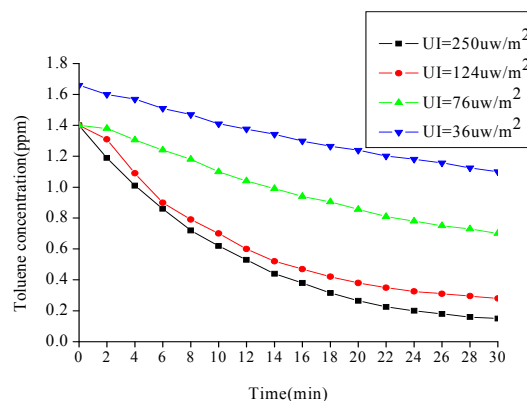


Fig. 9 Influence of different ultraviolet intensity (UI) on oxidizing formaldehyde

4.5 Effect of ultraviolet intensity on Active Carbon and Nano-titanium Dioxide Photocatalysis Purification Web Decomposing Toluene

From the figure 9, we can see that ultraviolet radiation is one of necessary factors that nano-titanium dioxide photocatalysis decomposes VOCs. With the ultraviolet intensity increased the efficiency of purification will be enhanced. The cause is that larger ultraviolet intensity will produce more and more active oxygen and free radical. But with the ultraviolet increased the efficiency of decomposing toluene exist certain limitation. intensity increased the efficiency of decomposing toluene exists certain limitation. So when the ultraviolet intensity grows from 124 w/cm^2 to 250 w/cm^2 , the efficiency is not obviously changed.

5 CONCLUSIONS

5.1 The purification efficiency of Active Carbon and

Nano-titanium Dioxide Photocatalysis Web is the highest through testing the changes of toluene concentration in three kinds of purification and it possesses stronger capability of absorption and decomposition on organic and inorganic contaminants.

5.2 Depending on the absorption of active carbon rapidly absorb and enrich onto surface the contaminations with low concentration and accelerate the velocity of photocatalysis decomposing contaminations and restrain the new contaminations to be produced.

5.3 TiO_2 photocatalysis cause the contaminations absorbed by active carbon to divert onto the surface of TiO_2 and renew the capacity of active carbon absorption and realize the regeneration on the same place.

5.4 To Active Carbon and Nano-titanium Dioxide Photocatalysis Web, the influence of airspeed on purification efficiency is not obvious. The difference of cleaning efficiency is less than 9% when the airspeed is at high and low velocity.

5.5 To Active Carbon and Nano-titanium Dioxide Photocatalysis Web, higher the original concentration, more obvious the cleaning efficiency is. But it is still higher the cleaning efficiency than other single purification technique when contaminations concentration is very low.

5.6 Higher temperature, the higher efficiency of decomposing toluene is. When the air temperature is 25, the effect of photocatalysis is optimal.

5.7 With the ultraviolet intensity increased the photons

and more active oxygen and free radical. But with the ultraviolet increased the efficiency of decomposing toluene exist certain limitation.

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